Suppressing oriental fruit fly populations with phloxine B-protein bait sprays

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Abstract: The oriental fruit fly, *Bactrocera dorsalis* (Hendel), is a tephritid fruit fly that is a serious pest of a wide range of tropical fruits. Populations of oriental and other fruit fly species are often suppressed by utilizing aerial or ground sprays of hydrolysed protein bait mixed with malathion. Although proven to be efficacious, spraying food bait mixed with malathion in urban areas is strongly opposed by the public because of perceived public health and environmental risks. To suppress the population level of oriental fruit fly in a guava orchard in Hawaii, we used the light-activated xanthene dye, phloxine B (2′,4′,5′,7′ -tetrabromo-4,5,6,7-tetrachlorofluorescein, disodium salt), as an alternative to malathion in protein bait sprays. Because phloxine B must be ingested to be toxic, it is expected that phloxine B bait sprays will have less impact on non-target insects than the contact insecticide malathion. Evidence of suppression of oriental fruit fly population in the treatment orchard was provided by both protein bait trap catches and assessment of fruit infestation. This suppression was achieved even though there was an unsprayed guava orchard on two sides of the small (less than 2.0 ha) sprayed orchard. These results, combined with results for other fruit fly species (presented elsewhere), indicate that phloxine B-protein bait sprays can be effective in suppressing populations of several different fruit fly species and that phloxine B is a potential replacement for malathion in bait sprays for tephritid fruit fly suppression/eradication programs.

Keywords: *Bactrocera dorsalis*; tephritidae; oriental fruit fly; xanthene dye; phloxine B

1 INTRODUCTION

The oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) is widely distributed in Oriental Asia, Guam and Hawaii, where it is a serious pest of a wide range of tropical, subtropical, and temperate fruit crops.[1] Populations of oriental and other fruit fly species are often suppressed by utilizing aerial or ground sprays of hydrolysed protein bait mixed with malathion. While these are efficacious, spraying food bait mixed with malathion in urban areas has met with very strong public opposition because of public health and environmental concerns. Light-activated insecticidal action of several halogenated xanthene dyes against a number of species in the laboratory and field has been documented.[2] The xanthene dye, phloxine B (2′,4′,5′,7′-tetrabromo-4,5,6,7-tetrachlorofluorescein, disodium salt) has shown promise as an alternative to malathion in bait sprays and in male annihilation technology for the oriental fruit fly.[3] A specially purified grade of phloxine B (D&C Red No 28) has been used as a color additive in drugs and cosmetics in the United States.[4] The US Food and Drug Administration (FDA) has estimated a maximum acceptable daily intake for humans of D&C Red No 28 to be 1.25 mg day^{-1} per kg body weight.[5] In addition to its improved safety for humans relative to malathion, the use of phloxine B in bait spray should have significantly less adverse impact on non-arget organisms. Because phloxine B is active only when ingested, selectivity may be conferred by using a food bait that exerts strong attraction and phagostimulation to fruit fly adults but not to non-target organisms. In a test of six beneficial insects, the activity of phloxine B in bait solutions was significantly less against all test insects than that of malathion in the same bait solutions.[6] Here, we report on a field trial of the effectiveness of a phloxine B-protein bait spray for the suppression of oriental fruit fly in a guava (*Psidium guajava* L) orchard in Hawaii, USA.

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2 EXPERIMENTAL

2.1 Test site

The test was conducted in the Guava Kai guava orchard in the vicinity of Kilauea on the island of Kauai in Hawaii, USA. The treatment orchard (1.9 ha) was surrounded by abandoned guava orchard on two sides and by land not supporting host plants of the oriental fruit fly on the other two sides. The control orchard (1.4 ha) was surrounded by a guava orchard on one side and by land not supporting host plants of the oriental fruit fly on the other three sides. Guava tree spacing was 6.1 m within rows and 7.3 m between rows. Half-ripe fruits were harvested in both orchards up until the first spray and, thereafter, only in the control orchard.

2.2 Bait spray application

Phloxine B (94% purity) was obtained from Hilton-Davis (Cincinnati, OH, USA) and Provesta 621, an autolysed yeast extract, from Integrated Ingredients (Bartlesville, OK, USA).The bait spray was composed of phloxine B + Provesta 621 + water (0.5 + 12.0 + 87.5 by weight) and was applied at a rate of 12.5 liter ha^{-1} through Tee Jet 5500-X1 and 5500-X2 cone jet spray nozzles (one of each) (Spraying Systems Co, Wheaton, IL, USA) set to deliver a stream spray. The nozzles were mounted on an all-terrain vehicle (ATV). A pump maintaining a force of 3.5–4.2 kg cm^{-2} projected two bands of the dye-bait spray onto the underside of the foliage on two (opposite) sides of each guava tree. Weekly spraying began in the treatment orchard on 21 August 1997 and continued until 20 November 1997, for a total of 14 sprays.

2.3 Population assessment

2.3.1 Protein bait traps

Sixteen yellow-bottomed plastic dome traps (Biosys Inc, Palo Alto, CA, USA), baited with an aqueous solution of Provesta 621 ($100\,g\,kg^{-1}$) and borax ($30\,g\,kg^{-1}$) were set out in both the treatment and the control fields two months before the first spray. These traps were serviced weekly for six weeks following the last spray.

2.3.2 Ripe fruit collections

Ninety ripe fruits were collected weekly from both the treatment and the control orchards beginning 7 August 1997. Collections were continued through 30 December 1997, six weeks after the last spray. Following collection, fruits were processed for assessment of tephritid fruit fly infestation.

3 RESULTS

3.1 Trap catches

Oriental fruit fly populations started to increase in both treatment and control fields by 14 August 1997. This increase coincided with guava fruit ripening. As of the first day of spraying, average trap catches in the treatment (181) and the control (233) orchards were

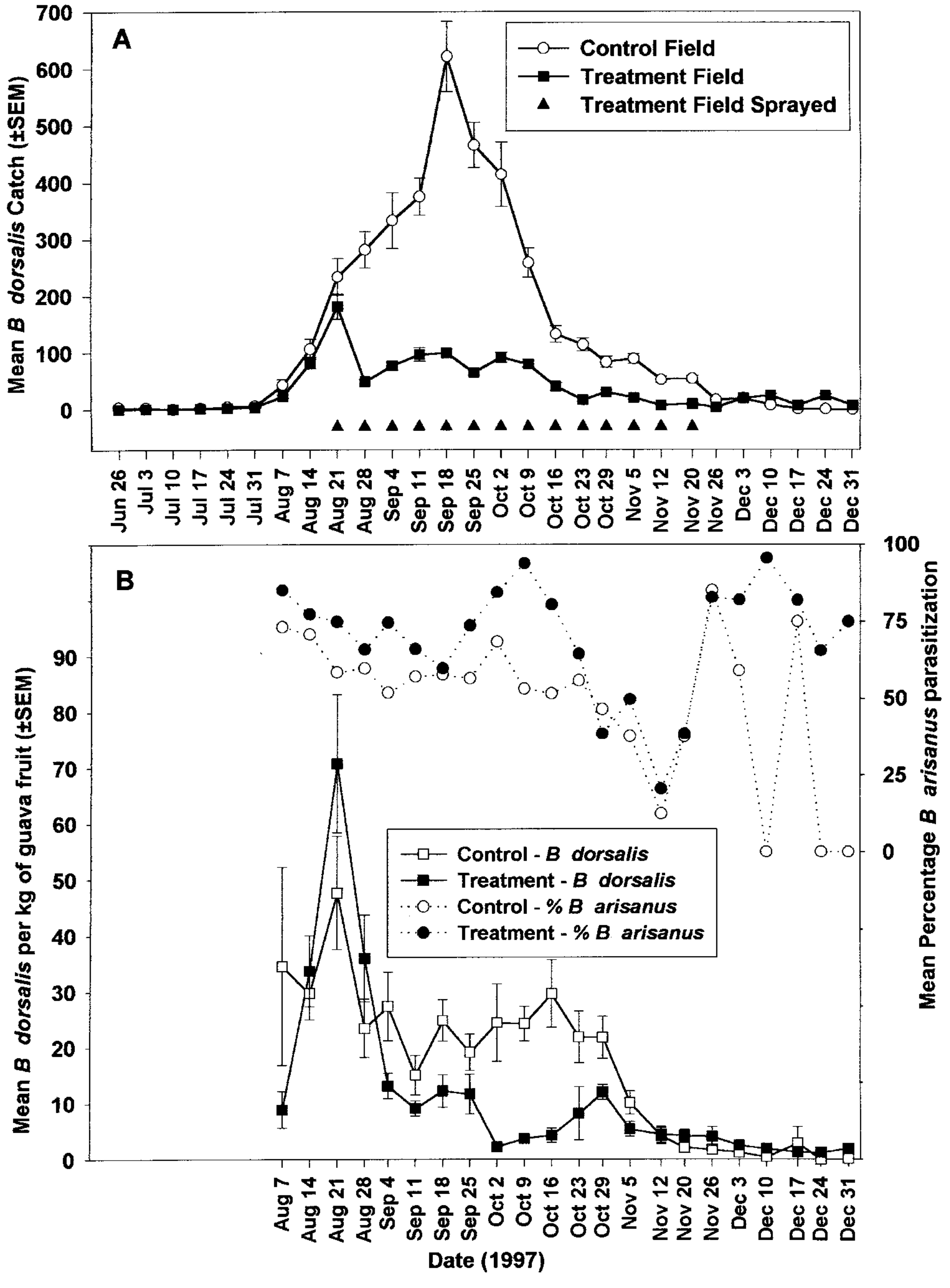

Figure 1. A. Mean (±SEM) catch of oriental fruit fly, *Bactrocera dorsalis* in treatment and control guava orchards before, during, and after weekly phloxine B-protein bait sprays. B. Mean (±SEM) infestation of oriental fruit fly, *Bactrocera dorsalis*, per kg of guava fruit recovered weekly from treatment and control orchards before, during, and after weekly phloxine B-protein bait sprays. The mean includes parasitoids which had parasitized eggs or larvae of oriental fruit fly (the parasitoid species found typically produce only one adult per parasitized individual). Percentage of oriental fruit fly individuals which were parasitized by *Biosteres arisanus* in both treatment and control orchards is also indicated. *B arisanus* accounted for 99.4% of all parasitization of *B dorsalis*.

not significantly different ($F = 2.20$; df = 1, 30; $P = 0.138$). The average trap catch in the control orchard continued to increase after this to a peak of 622 on the fifth week of spraying, while the average trap catch in the treatment orchard dropped during the week after the first spray and never exceeded 100 throughout the rest of the study (Fig 1A). The average trap catch in the treatment orchard was always significantly less than in the control orchard from the second week of spraying through the week after the last spray.

3.2 Fruit infestation

As of the first week of spraying, the average oriental fruit fly infestation (including parasitoids which had parasitized eggs or larvae of oriental fruit fly) was not significantly different in the treatment orchard (70.8 flies kg^{-1} guava) and in the control orchard (47.7 flies kg^{-1} guava) ($F = 2.09$; df = 1.16; $P = 0.168$). Fruit infestation subsequently dropped in both orchards, but the decrease was greater in the treatment orchard, so that the infestation there was significantly less on the 3rd, 5th, 7th, 8th, 9th and 11th weeks of spraying (Fig 1B), by which time the protein bait trap catches showed that the population level in the control orchard had fallen considerably (Fig 1A). Percentage parasitization of oriental fruit fly by *Biosteres arisanus* (Sonan) was typically higher in the treatment orchard throughout the study, averaging 55.1% in the treatment orchard over the last seven spray weeks, compared to 42.1% in the control orchard (Fig 1B), suggesting that the bait sprays were not adversely affecting the population of this parasitoid.

The results presented here suggest that phloxine B-protein bait sprays can suppress established oriental fruit fly populations and that phloxine B is a potential replacement for malathion in bait sprays for tephritid fruit fly suppression/eradication programs. However, more extensive tests are needed which limit immigration of adult flies and parasitoids from surrounding unsprayed areas.

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Synthesis and herbicidal activity of new benzenesulfonylureas

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Abstract: A series of benzenesulfonylurea derivatives possessing a branched hydroxymethyl moiety as an *ortho*-substituent were synthesized and found to have interesting herbicidal activity under submerged paddy conditions.

Keywords: benzenesulfonylureas; branched hydroxymethyl; K11451; submerged paddy conditions

In 1982, DuPont disclosed a patent[1] covering new benzenesulfonylurea herbicides possessing a hydroxymethyl sub-unit. However, the biological data in the patent did not indicate any distinct characteristics in terms of herbicidal activity and crop tolerance.

Recently, we developed a new synthetic method for sulfonylchlorides that could be utilized for the synthesis of a variety of sulfonylurea compounds.[2] During the programme aimed at developing a new type of sulfonylurea herbicide, we synthesized a series of benzenesulfonylurea derivatives possessing a branched hydroxymethyl moiety as an *ortho*-substituent, employing the new method and procedures from the literature[3] and found that the compounds had interesting herbicidal activity (Fig 1; Table 1).[4]

In method A (Fig 1) *o*-bromophenyl methoxymethyl sulfide was lithiated using *n*-butyl lithium by a metal–halogen exchange reaction and reacted with an electrophile. The resulting hydroxyalkyl-sybstituted phenyl methoxymethyl sulfide was protected using acetic anhydride (carbonyl compounds were reduced before protection) and the protected sulfide was then converted into the corresponding sulfonamide via successive chlorination-amination reactions. The sulfonamide was then coupled with carbamate, using a conventional method, and the acetyl group was

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